



Defense, Space & Security  
Lean-Agile Software

# The Road to Agile Systems Engineering

**Presented by:**  
**Rob Simons and Philip Matuzic**

**Contributors:**  
**Dick Carlson and Don O'Connell**

Report Documentation Page			Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.				
1. REPORT DATE <b>MAY 2011</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2011 to 00-00-2011</b>
4. TITLE AND SUBTITLE <b>The Road to Agile Systems Engineering</b>		5a. CONTRACT NUMBER		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)		5d. PROJECT NUMBER		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Boeing Defense, Space &amp; Security,PO Box 516,St. Louis,MO,63166</b>		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>				
13. SUPPLEMENTARY NOTES <b>Presented at the 23rd Systems and Software Technology Conference (SSTC), 16-19 May 2011, Salt Lake City, UT. Sponsored in part by the USAF. U.S. Government or Federal Rights License</b>				
14. ABSTRACT <b>&amp;#56256;&amp;#56451; Systems Engineering for large, high-technology, aerospace programs is scope historically complex and broad in scope. &amp;#56256;&amp;#56451; We present a logical and practical path toward leaner and more agile systems engineering beginning with a high-level overview of typical systems engineering processes. Emphasis is on activities and processes amenable to improvement by adapting Agile practices. &amp;#56256;&amp;#56451; This presentation is limited to a small subset of early SE activities &amp;#56256;&amp;#56451; This presentation shows example candidate areas that can benefit from the application of Agile practices, and identifies efforts currently underway to apply these practices to new and ongoing development.</b>				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>24</b>
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>		

# Abstract

Boeing Defense, Space & Security | Lean-Agile Software

- Systems Engineering for large, high-technology, aerospace programs is historically complex and broad in scope.
- We present a logical and practical path toward leaner and more agile systems engineering beginning with a high-level overview of typical systems engineering processes. Emphasis is on activities and processes amenable to improvement by adapting Agile practices.
- This presentation is limited to a small subset of early SE activities
- This presentation shows example candidate areas that can benefit from the application of Agile practices, and identifies efforts currently underway to apply these practices to new and ongoing development.

*“Agility is the ability to both create and respond to change in order to profit in a turbulent business environment.” – Jim Highsmith*



# First, a Primer: Key Focus of Systems Engineering

Boeing Defense, Space & Security | Lean-Agile Software

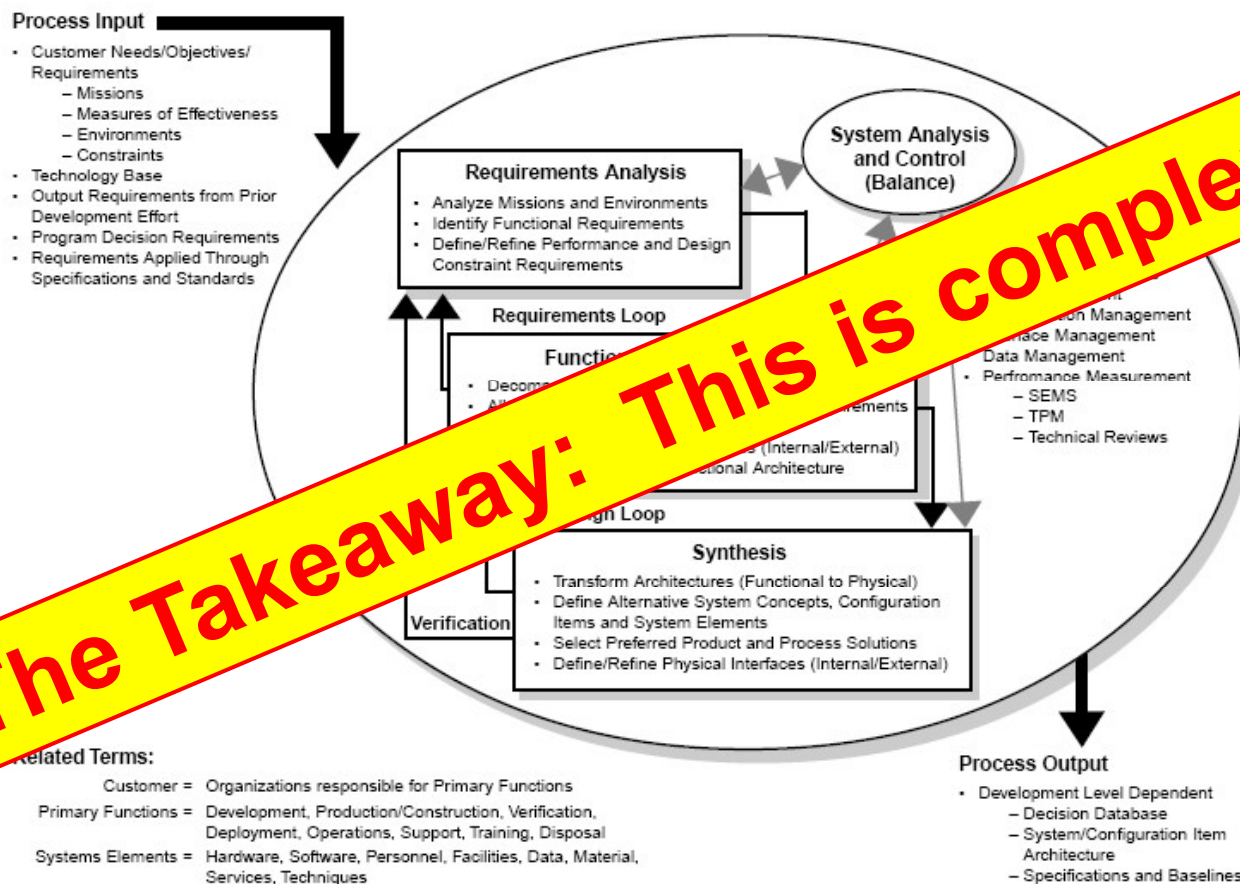
## Drivers for Agile Systems Engineering

Leverage “lighter weight” tailored Systems Engineering process for urgent needs, rapid fielding and technology insertion....accelerate delivery of technical capabilities to win the current fight by using agile SE to incrementally / quickly evaluate changing requirements

# The SE 'Engine' from an Ops Analysis Perspective

Boeing Defense, Space & Security | Lean-Agile Software

- SE is process-based and often influenced



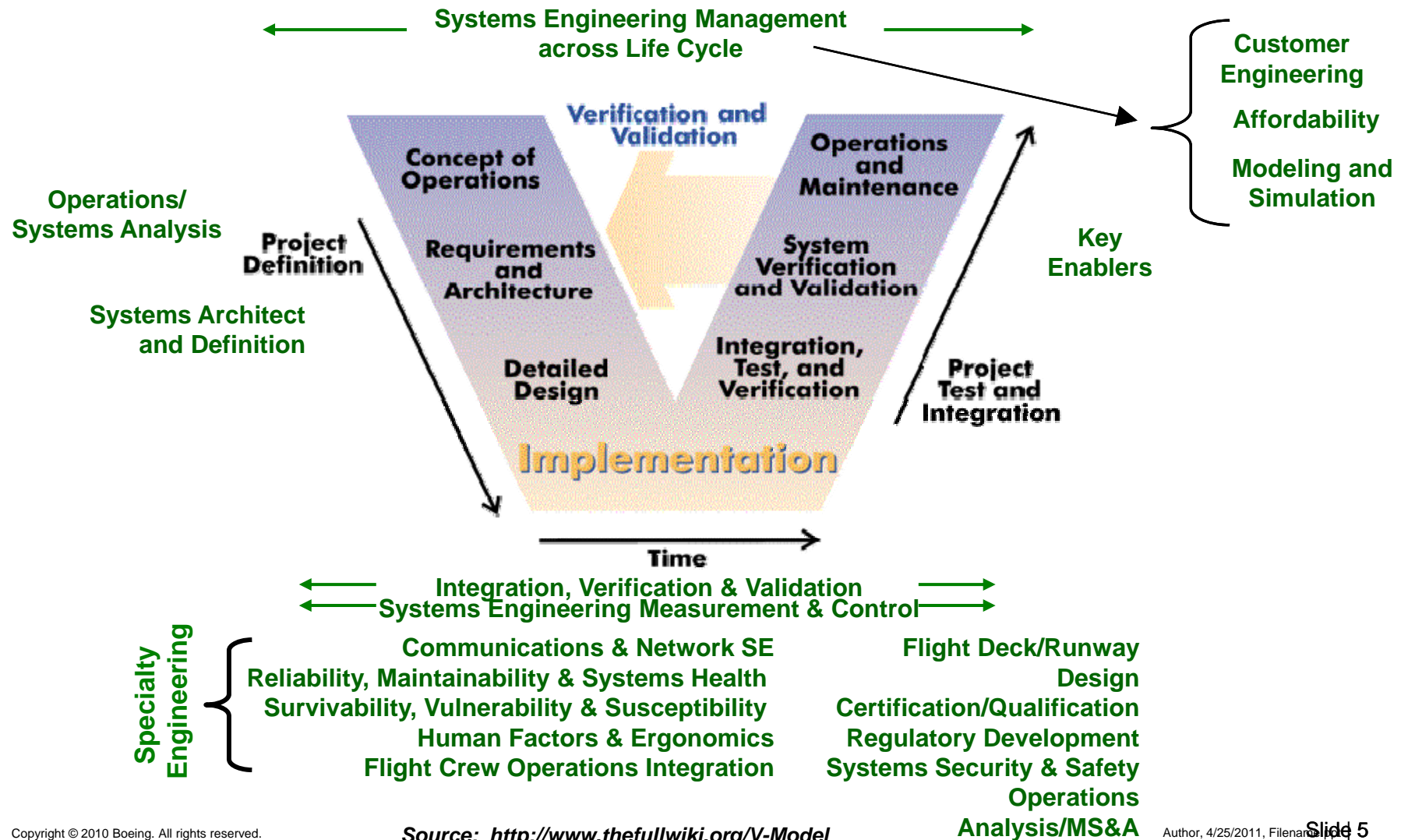




# Where to Start? An Aerospace Big Picture View

## Systems Engineering views SE involvement across a product life cycle

Boeing Defense, Space & Security | Lean-Agile Software





# Look to Early Product Life Cycle Activities

Boeing Defense, Space & Security | Lean-Agile Software

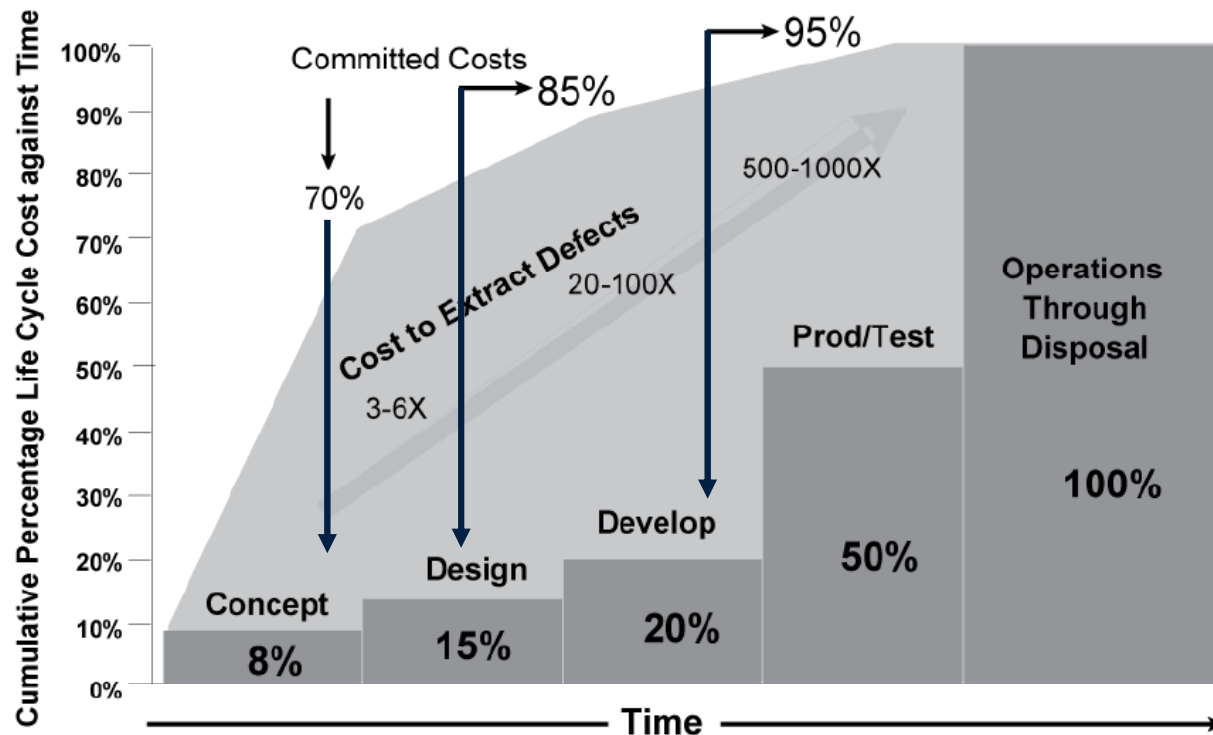
- **If you accept that:**
  - Agile has been successful with software because it is 'soft'\* and lends itself to the qualities of Agile and Scrum
  
- **Then you could accept that:**
  - Some Systems Engineering activities produce 'soft' artifacts that support HW activities (where Agile is more difficult to instantiate) and could be candidates for 'agilizing'
  
- **Where can you find many examples of 'soft' Systems Engineering activities?**
  - In the early 'Front End' Conceptual Phase

\*'Generally describes elements and activities that produce artifacts with a high degree of flexibility and latitude in its definition, execution, and outputs, such as studies and analyses.'



# The Importance of SE at the Front End of Programs

Boeing Defense, Space & Security | Lean-Agile Software



Committed Life-Cycle Cost vs. Time

The percentages along the time line represent the actual life-cycle cost (LCC) accrued over time based on a statistical analysis performed on projects in the U.S. Department of Defense (DOD) as reported by the Defense Acquisition University

As shown, the Concept Stage of a new system averages 8% of the total LCC.

The curve for committed costs represents the amount of LCC committed by project decisions.

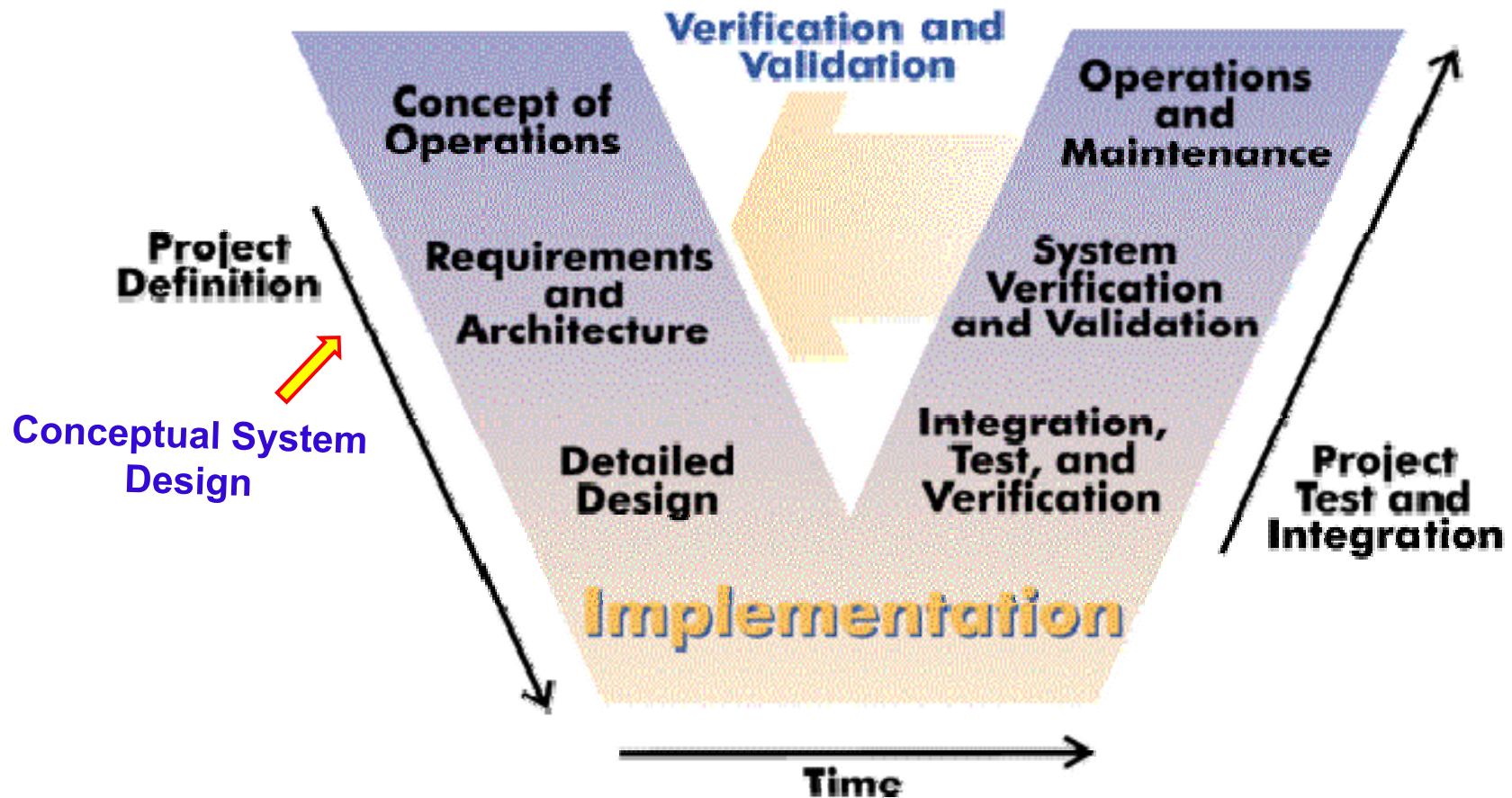
INCOSE SE Handbook, pg. 15: “[This] figure also demonstrates the consequences of making early decisions without the benefit of good information and analysis. SE extends the effort performed in concept exploration and design to exceed the percentages shown in the cumulative committed cost curve and reduce the risk of hasty commitments...”

Source: INCOSE Systems Engineering Handbook v. 3.2, January 2010; INCOSE; Defense Acquisition University, 1993



# What does SE do in the Front End?

Boeing Defense, Space & Security | Lean-Agile Software



Source: <http://www.thefullwiki.org/V-Model>



# Conceptual System Design Phase Activity

Boeing Defense, Space & Security | Lean-Agile Software

## Examples:

- Early Problem Definition & Need Identification
- Advanced System Planning
- Evaluation & Trade Studies
- System Feasibility & Requirements Analysis
- Measures of Effectiveness/Technical Performance Measures  
**(MOE / TPM) Investigation**
- Output Supports Modeling and Simulation activities
- Culminates in a Conceptual Design Review



# An Agile SE Example: Trade Studies

Boeing Defense, Space & Security | Lean-Agile Software

- Trade Studies at early program stages are often oriented towards determining technical feasibility and focusing on reducing the solution space
- Activities include articulating the purpose, identifying scope and constraints, etc.
- Trade Studies are applicable to each level of the system architecture
- Application examples include technologies, suppliers, 'boxes', etc.



# Applying Agile to the Trade Study Downselect Alternatives Process

Boeing Defense, Space & Security | Lean-Agile Software

- **Identify evaluation criteria & weighting factors iteratively**
  - Define purpose, scope, constraints, assumptions
  - Identify initial list of alternatives
  - Apply evaluation method for analyzing initial list of alternatives
- **Downselect alternatives iteratively**
  - Apply evaluation method for analyzing initial list of alternatives
- **Perform detailed analysis iteratively**
  - Apply evaluation method for analyzing initial list of alternatives
- **Identify recommended alternatives**

# Agile Systems Engineering Trade Study

Boeing Defense, Space & Security | Lean-Agile Software

## General Steps of a Trade Study:

- Define the purpose of the trade study
- Plan the trade study
- Describe the assumptions for the trade study
- Define the evaluation criteria and assign weighting factors
- Identify and develop alternatives
- Evaluate alternatives against the evaluation criteria
- Recommend a decision based on the evaluation of the alternatives
- Document recommendations and rationale in a report
- Review and accept/reject the trades study recommendations and report

## Suggested AgileSE Trade Study

- Implements most of the Agile practices and principles
- Applies the Scrum framework where roles, activities, and artifacts are essentially the same
- At the end of each iteration, the product backlog “baseline” has evolved into a clearer and more complete set of requirements
- Acceptance tests are written for each backlog item (dependent upon the type of TS)
- Attributes, constraints, and dependencies are identified
- All data is managed and controlled

Source: INCOSE Systems Engineering Handbook v. 3.2, January 2010;  
INCOSE; Defense Acquisition University, 1993



# Agile Systems Engineering will Challenge the Paradigm

Boeing Defense, Space & Security | Lean-Agile Software

## Recommendations:

- Find a Champion
- Look for SE opportunity areas early in the Lifecycle
- Look for discrete job chunks that can be easily defined & are amenable to implementing Scrum practices
- Consider selecting a bounded pilot project executing a specific activity (such as a TS)
  
- Suggest developing Agile Checklists that reflects your AgileSE concerns:
  - Level of Uncertainty & Agility Needed
  - Cost, Risk (Assessment of Risk is key)
  - Metrics to gauge progress, improvement, and satisfaction
  
- Recognize that you will want to deliver the *product needed* at the end and not necessarily what was *requested* at the beginning



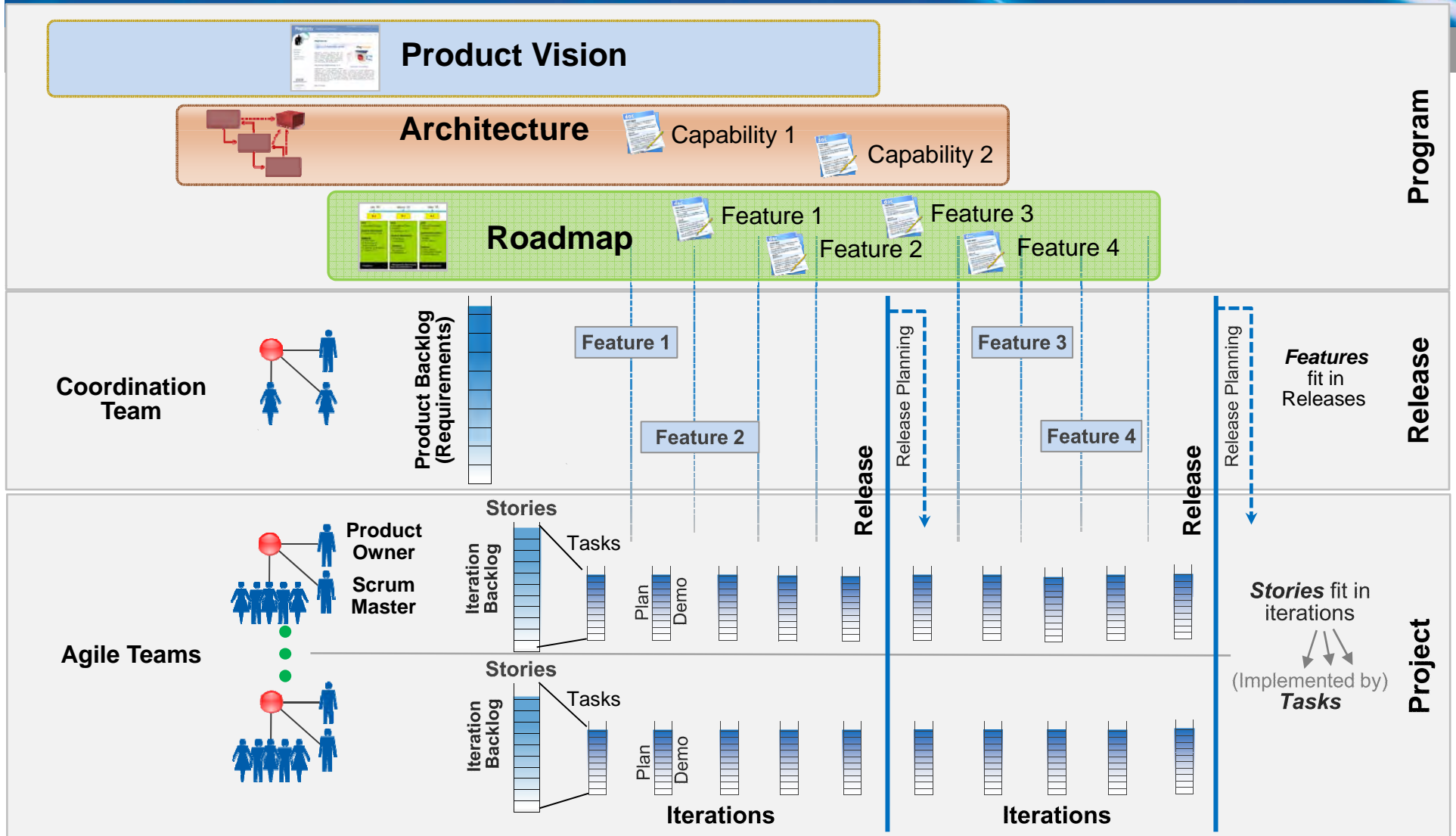


# Challenges Going Forward

Boeing Defense, Space & Security | Lean-Agile Software

- **Cultural acceptance of Agile within Systems Engineering**
- **Acceptance of AgileSE from Acquisition & Contractual organizations**
  - Oversight, Documentation, Detailed Planning issues
- **Expanding Agile to successfully address mid-late product life cycle issues**
  - Applicability of Agile methods and practices to Prototyping, Manufacturing, Production, etc.
- **Educating SE Leadership and Teams on implementing, practicing, and sharing successful AgileSE implementations**

# Software Architecture in Agile





# Experience in 2007-2009: Agile Software Requirements

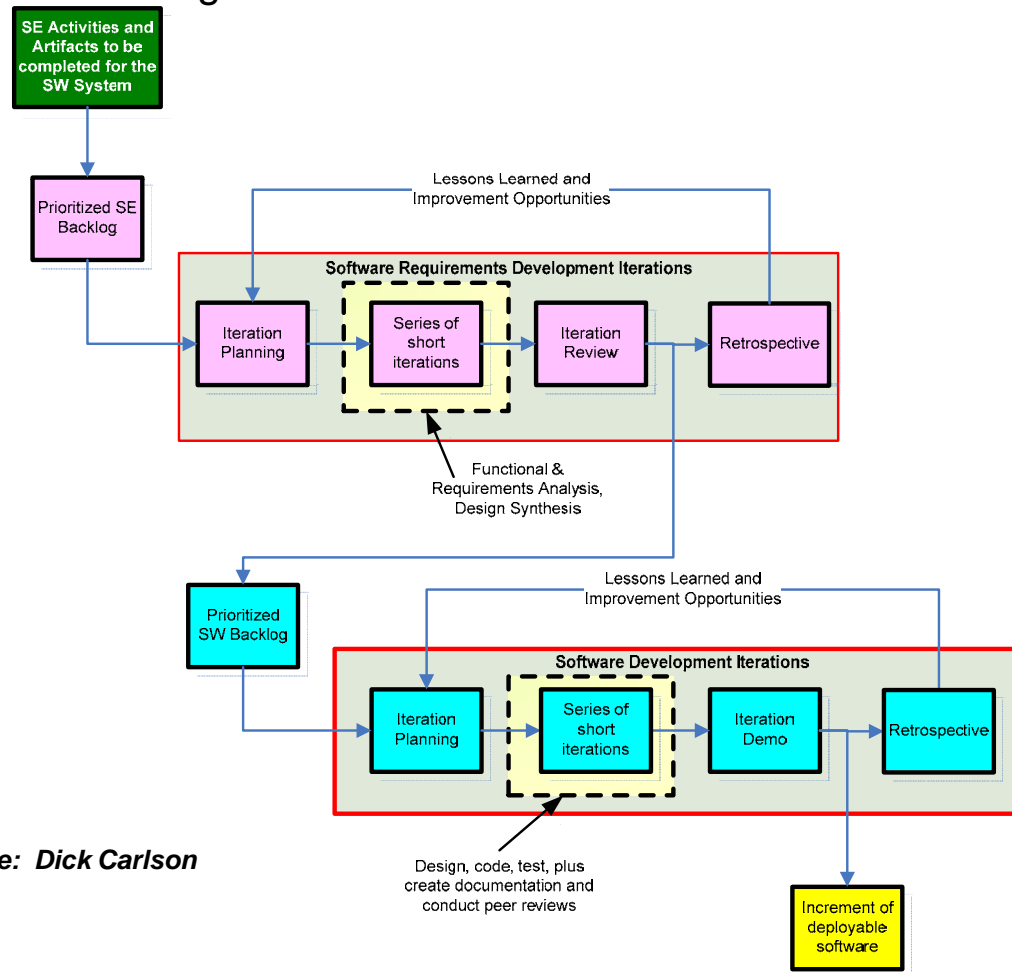
Boeing Defense, Space & Security | Lean-Agile Software

- **System development that required modifying a large enterprise COTS application across several engineering domains**
- **A more efficient approach was needed**
- **A release plan was established aligned to the scheduled mandate**
- **The Agile Scrum approach was selected to manage the project**
- **Teams were staffed with system engineers to develop software requirements through a series of 4-week iterations**

# Process Development in 2010

Boeing Defense, Space & Security | Lean-Agile Software

- The model below illustrates a much tighter collaboration between Agile system engineering teams and Agile software teams



Source: Dick Carlson



# Process and Direction Going Forward

Boeing Defense, Space & Security | Lean-Agile Software

- **The direction now is to define specific Agile practices that can be used to enable more efficient activities for the larger system engineering effort**
- **Develop several Agile templates of typical SE artifacts**
  - SEMP
  - Trade Study
  - IV&V
  - Etc.
- **Organize and prioritize SE activities and develop SE artifacts by implementing Agile practices:**
  - Active customer participation
  - Short daily stand-up meetings
  - Planning and estimating
  - Frequent deliveries
  - Short iterations
  - Prioritized requirements
  - Artifact reviews
  - Self-organized teams
  - Frequent delivery
  - Simplicity
  - Sustainable pace



Boeing Defense, Space & Security | **Lean-Agile Software**

# Questions?





Boeing Defense, Space & Security | **Lean-Agile Software**

# Backup



# Agile Principles and Practices

Boeing Defense, Space & Security | Lean-Agile Software

- Agile is a philosophy defined by principles and practices that drive quick delivery of quality software and encourage user feedback

## Principles:

- |                                |                          |
|--------------------------------|--------------------------|
| ■ Customer Satisfaction        | ■ Embrace Change         |
| ■ Frequent Delivery/Deployment | ■ Collaboration          |
| ■ Motivated Team               | ■ High Bandwidth         |
| ■ Working Software             | ■ Sustainable Pace       |
| ■ Technical Excellence         | ■ Simplicity             |
| ■ Emergent Design              | ■ Continuous Improvement |

## Practices:

- |                                |                            |
|--------------------------------|----------------------------|
| ■ Close customer collaboration | ■ Short iterations         |
| ■ Daily stand-up meetings      | ■ Test-driven development  |
| ■ Continuous integration       | ■ Prioritized requirements |
| ■ Automated testing            | ■ Product demonstrations   |
| ■ Planning and estimating      | ■ Self-organized teams     |

Source: Agile Alliance ([www.agilealliance.org](http://www.agilealliance.org))



# Agile Practices Often Used

Boeing Defense, Space & Security | Lean-Agile Software

- **Continuous planning**
  - **Short iterations (2 to 4 weeks)**
  - **On-site customer or proxy**
  - **Self-organized teams**
  - **Pair programming**
  - **Small releases**
  - **Prioritized requirements**
  - **Automated testing**
  - **Refactoring**
  - **Continuous integration and CM**
  - **Test first**
  - **Simple, robust design**
  - **Daily stand-ups**
  - **Feature-based planning**
  - **Information radiators**
  - **Inspections**
  - **Monitor and adjust**
  - **Retrospectives**
  - **Risk management**
  - **Unit testing**
  - **User stories**
  - **Empowered team**
  - **Bottleneck management**
  - **Demonstration**
- Source: Agile Alliance ([www.agilealliance.org](http://www.agilealliance.org))*



# Some Lessons Learned

Boeing Defense, Space & Security | Lean-Agile Software

- Focused, face-to-face iteration sessions improve team synergy
- Appoint someone to maintain specified time boxed activities
- First estimating round should focus on perceived size, complexity, or difficulty (in nebulous units)
- Scrum Master should work with management to resolve unplanned organizational impediments that affect work tasks
- Avoid side discussions that disrupt team momentum
- Attend all daily stand-ups (best way to know health and progress of team)
- Working as a team helps everyone understand tasks and how to formulate stories
- Team consultations with domain SMEs help clarify misunderstandings
- Ensure requisite architecture, infrastructures, technologies, and tools are in place before starting team activities



# Common Agile Terms

Boeing Defense, Space & Security | Lean-Agile Software

- **Agile**
- **Burndown Chart**
- **Daily Scrum**
- **Iteration or Sprint Backlog**
- **Iteration Planning**
- **Product Backlog**
- **Product Owner**
- **Scrum**
- **ScrumMaster**
- **Story**
- **Sprint**
- **Task Board**
- **Team**